THE MEANING AND ASSESSMENT OF INTELLIGENCE*

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Current Criticisms

DURING the last two or three decades the use of intelligence tests has spread with a rapidity that would have seemed incredible fifty years ago. It is therefore not surprising that many people have begun to ask how far the evidence really justifies these widespread applications. Some of the more vigorous criticisms have come from psychologists themselves. Unfortunately, however, neither critics nor supporters seem to have a very clear notion of what intelligence implies or what are the limitations to which the tests in current use are subject.

Most of them apparently suppose that there is a distinct mental quality which every man of the world can recognize and identify as intelligence, but that no one can say precisely in what that quality consists. Dr. Blackburn, for example, declares (and probably many teachers and doctors would agree with him) that "we all have some idea of what we mean by 'intelligence'; it is when one comes to define it that the difficulties arise." Others, however, flatly deny that there is any such thing: the concept of "general intelligence," they say, was invented by a small group of statistical psychologists (Dr. Kirman mentions Pearson, Spearman and myself), who derived the idea from a mathematical analysis of test-data by a fallacious method of deduction that has since been exploded. Dr. Heim, in her recent book on *The Appraisal of Intelligence*, seeks to combine both these views. "The supporters of factor analysis," she writes, "treating their technique as an end in itself," have "taken a popular and relatively unambiguous word, and tried to restrict its meaning": they equate it with an abstract "factor". When pressed to say in what this factor consists, every psychologist gives a different reply. And, she adds, during the last few years the statistical proofs on which the factorist has relied have been "publicly discussed and discredited".†

The Meaning of Intelligence

Now all these criticisms rest on a mass of confusions, and entirely overlook the true history of the subject. A mere glance at the relevant literature will quickly show that intelligence is not a conception "introduced by a small group of statistical psychologists." Nor is the term itself "a word of popular speech" whose meaning has recently been restricted and distorted by psychological specialists. It is, and always has been, a technical term introduced to designate a technical concept. And the concept itself has been reached and clarified by inquirers working along half a dozen different lines. Observational psychology, introspective psychology, experimental psychology, the speculations of the biologist, the theories of the neurologist, and finally the objective study of individual differences, each has contributed valuable evidence. The application of statistical methods has come only at the very end; their function has mainly been to decide between alternative explanations of certain observable facts, and so to clinch and confirm what had been provisionally inferred on far more concrete grounds.

* The Galton Lecture delivered on May 4th, 1955.

† J. Blackburn, *Psychology and the Social Pattern*, 1945, chap. V, "Intelligence and Ability"; B. Kirman, *This Matter of Mind*, 1952, pp. 67 f.; Dr. Heim, like many other critics, quotes the American symposium in which fourteen psychologists were asked to explain "what I conceive intelligence to be" (not, be it noted, to *define* the word), and gave "fourteen different replies" (*J. Educ. Psychol.*, 1921, **12**, pp. 123-147, 195-216). But this was a quarter of a century ago, when (owing largely to the war) very little research had been attempted.

May I therefore begin by briefly tracing the history of the concept ?

1. Observation and Introspection

The basic notion goes back to the days when the human mind first became the subject of philosophic curiosity. Plato, a shrewd observer of individuals, was, as Galton has so often reminded us, the first to recognize the social implications of mental heredity and to advocate something very like a eugenic policy.* His psychological disquisitions are incidental and sporadic ; but they had a profound influence on later thought.

He draws a clear contrast between " nature " and " nurture " (*φύσις* and *τροφή*) ; and he then goes on to distinguish three " parts " of the soul—the " rational " or intellectual (*τὸ λογιστικόν*) having its seat in the brain, and " appetite " (*ἐπιθυμία*) and " spirit " (*θυμός*) located respectively in the belly and chest. This threefold distinction has often been compared with the modern distinction between " cognition," " affection," and " conation "—the intellectual, emotional, and moral elements in human behaviour. But none of these modern terms accurately expresses what Plato was trying to convey. In a famous passage (*Phaedrus*, 253D) he uses an analogy which gives a better notion of the difference : the first element he compares to the charioteer who holds the reins, and the others to a pair of horses who draw it : the former guides, the latter provide the power ; the former is the *cybernetic* element, the latter the *dynamic*.

And, says Plato, since men differ so widely in their innate characteristics, they should, from childhood upwards, be subjected to tests, so that each can be educated, and eventually employed, as his native gifts require. The rulers are to be men pre-eminent for their intellectual capacity or " wisdom "—" men of gold rather than of silver, iron, or brass ".

Thus, for Plato the natural inequality of man is itself one of the most profound and ill-recognized of all political problems. It threatened the democracy of Athens, and it threatens the democratic state today : " it is the source at once of the injustice that we must seek to correct and of the justice or civic harmony that will enable us to correct it ".‡ Plato would have his citizens believe, " as though an oracle had foretold it, that the city will perish when men of iron or brass take over its control " (*loc. cit.*, 415C) : or, as he puts it elsewhere, " the ship of state is bound to founder if the unruly crew, whose job it is to manage the sails, but who are in no way ' cybernetic ' (i.e. good at finding and steering a course), selfishly seize the helm " (*loc. cit.*, 488B).

Aristotle's discussion is more methodical, and issues in a more systematic classification. Here for the first time§ we meet a clear distinction between actual process and mere capacity or " power "‖ (*δύναμις*). While lecturing I am actually talking ; when asleep, I have the power to talk ; when newborn, " with no language but a cry ", I have the power to acquire the power to talk. The distinction is of course applicable in non-psychological fields as well as psychological : as applied to the latter it is the basis of our concept of mental capacity.

In what is virtually the first textbook of psychology Aristotle substitutes a twofold classification for Plato's threefold ; and his main contrast is drawn between what he calls the " dianoetic "¶ (cognitive or intellectual) capacities of the mind and the " orectic " (emotional and moral). The cognitive capacities manifest themselves at four successive levels—sensation, imagination, memory, and reasoning. All have the

* Cf. *Republic*, 435A f., 509C f. ; and R. L. Nettleship, *Lectures on the Republic of Plato*, chap. XI.

† The word *εὐγένεια* is actually used towards the end of the *Republic*, 618D.

‡ Walter Pater, *Plato and Platonism*, p. 242 (the alternative title of the *Republic* is " On Justice ").

§ Aristotle, *Metaphysics*, Bk. VIII, passim.

‖ The regular translation " power " is perhaps a little unfortunate: *δύναμις* (from *δύναμαι*, " I can ") is " power " in the sense of " ability " or " potentiality ", not of " force ". It denotes what Professor Broad has called a " dispositional property ".

¶ Liddell and Scott's *Dictionary* gives " intelligence " as the obvious rendering of this word in Plato and Aristotle. The preposition *dia-* has something of the force of the Latin *dis-* ; and Aristotle notes that " sensation " *discriminates* between the qualities of things.

common quality of τὸ διανοητικόν*. There is, however, no sharp separation between the various levels or the different parts or faculties. " Soul in fact is homœo-merous, like a tissue " (i.e. it is not a collection of distinct organs) : " with Aristotle sensation is regarded as itself a discriminative capacity from which the higher acts of cognition are reached by a continuous development ".† Throughout, it will be noted, Aristotle formulates his classification of mental activities in terms of conscious contents, and so gives it an introspective rather than a behaviouristic character—a bias which has only recently been corrected.

Cicero, in his endeavour to provide a Latin terminology for Greek philosophy, translates δύναμις by *facultas*, ὄρεξις by *appetitio* or sometimes *conatus*, and to designate διανόησις he coins a new word, rendering the Greek term almost literally by the compound " intellegentia " (i.e. inter-legentia). His definition is : " Intellegentia est, per quam animus ea perspicit quæ sunt ".‡

Here then we have the origin of both the concept and the term. From Aristotle and Cicero they descended to the mediæval schoolmen ; and the scholastic theories in turn developed into the cut-and-dried schemes of the faculty psychologists and their phrenological followers.§ All of them continued to contrast intellectual capacities, which they termed abilities or " faculties," with emotional or moral capacities, which they termed " propensities " ; but none recognized any " general " ability over and above the more specific faculties. And according to the phrenologists each distinguishable mental function was due to the activity of a separate " organ " or " centre " in the brain. The whole picture is one that Plato would instantly have repudiated, since he himself ridicules those who thought of the mind as a sort of " Trojan horse ", containing within itself a collection of active homunculi, each with its own special task (*Thæetetus*, 184D). Although the later psychologists of the nineteenth century, including both associationists and their critics, were united in rejecting it, the traditional theory of faculties continued to enjoy a considerable vogue among medical and educational writers. To this day, indeed, teachers, educational officials, school medical officers and psychiatrists constantly drop into the vocabulary of the faculty school when they attempt a character-sketch of any child or patient ; and contemporary critics of the concept of " intelligence " regularly assume that its sponsors intend it as yet another " faculty " in the sense defined by the Scottish philosophers and their physiological interpreters.

2. Biological

In this country the conversion of psychology from a branch of philosophy into a branch of natural science was the work not of the physiologists but of the biologists, particularly the leaders of the evolutionary school—Spencer, Darwin and their disciples. Spencer, following Aristotle and the Thomists rather than Plato and Kant, recognized only two main aspects of mental life—the cognitive and the affective. All cognition (he explains) involves both an analytic or discriminative and a synthetic or integrative process ; and its essential function is to enable the organism to adjust itself more effectively to a complex and ever-changing environment. During the evolution of the animal kingdom, and during the growth of the individual child (which, he assumes, briefly recapitulates the evolution of the race), the fundamental capacity of cognition

* *De Anima*, II, 3, 414a 31. Cf. *Eth. Nic.*, I, 13, 18, 1102b 30, where human excellencies are classified as " ethical " and " dianoetic ".

† W. D. Ross, *Aristotle*, 1923, pp. 133, 136; *De Anima*, I, v, 411b 5.

‡ Cicero, *Inv. Rhet.*, II, 53. The word is sometimes coupled with *cognitio* as a synonym (Cic., *Tusc. Disp.*, V, 24). But it is used of the humblest forms of " discernment " (e.g., taste and smell) and of " discernment " involved in practical activities (cf. *Acad. Quæst.*, IV, 7, and *Inv. Rhet.*, I, 29).

§ The leader of this school—the " systematizers " as they are sometimes called—was the German philosopher, Christian Wolff (1734: for his scheme, see Wundt, *Grundzüge*, p. 97). In Britain its chief representatives were the Scottish philosophers, Reid (1780) and Stewart (1827). The inventories of " mental powers " drawn up by these last two writers form the basis of the phrenological lists published by Gall, Spurzheim, and George Combe (*Lectures on Phrenology*, 1847).

becomes progressively more and more specialized and more and more comprehensive, and so differentiates into a hierarchy of cognitive abilities—sensory, perceptual, associative, and relational, much as the trunk of a tree sprouts into boughs, branches, and twigs. To designate the basic quality common to all these more specific forms he adopts the term "intelligence."*

Spencer's evolutionary theories were at first taken up with keener enthusiasm on the Continent than in this country. Taine, the leader of the new empirical school in France, expounded them in his monograph *De l'intelligence* (1870); Ribot amplified them still further in *L'heredité psychologique* (1873); and their version provided the starting point for the work of their more celebrated disciple, Alfred Binet (*L'étude expérimentale de l'intelligence*, 1903, and later papers). In Switzerland Spencer's views inspired the genetic studies of Claparède and of his pupil, Jean Piaget. Both these adopt a standpoint that is frankly biological. Piaget, in language reminiscent of Plato, contrasts the "directive" and "dynamic" elements in mental life: "every action," he says, "involves an energetic or affective aspect, and a structural, regulative, or cognitive aspect. . . . Intelligence is not a faculty: it is the generic term indicating the organism's relative efficiency in organizing or structuring mental activity in order to adjust itself to changing circumstances". And he propounds, as a result of first-hand observations of the developing child, a hierarchical theory of "levels", less schematic and more exact, yet on the whole strikingly similar to that of Herbert Spencer.†

3. Physiological

While in France and Britain scientific psychology was regarded as a branch of biology, in Germany it was treated as a branch of physiology. The earliest experiments on cerebral localization seemed to indicate something rather like a modified phrenological theory—the functions localized in the various cortical areas being of a somewhat simpler kind than the traditional faculties. Wundt quotes with approval Spencer's principle that mental organization merely reflects the underlying neurological organization, and consequently regards *Intelligenz* as a property of the central nervous system. There is, however, no *localized* "Organ der Intelligenz": *Intelligenz* is "simply a name for the varying degrees of efficiency in the fundamental cognitive process"—a process which he prefers to call "apperception"—i.e. "attention regarded as a process of synthesis". It operates on various levels; and he too gives a schematic diagram of the way the nervous system is organized, plainly suggested by Spencer's description.‡

Wundt's scheme is avowedly hypothetical. But later studies of the structure and functions of the nervous system went far to confirm the general accuracy of these views. The clinical work of Hughlings Jackson and the experimental investigations of Sherrington lent strong support to the theory of a "neural hierarchy",§ with a definite order of evolution for the various levels. Within the adult brain there are marked differences in the architecture of different parts and of the different cell layers clearly discernible under the microscope; and these differences or specializations emerge progressively during the earliest months of infant life.‖ At the same time, the examination of the cortex in mental defectives and in normal persons indicates that the quality of the nervous tissue in any given individual tends to be predominantly the same throughout.

* H. Spencer, *Principles of Psychology*, 1870, I, esp. Pt. iv, chaps. 1 and 3, "The Nature of Intelligence" and "The Growth of Intelligence." Spencer's account was admittedly somewhat speculative; but it has in some measure been confirmed by the work of later experimentalists (like Lloyd Morgan) and contemporary child psychologists (like C. W. Valentine).

† J. Piaget, *The Psychology of Intelligence* (1950), and *The Origin of Intelligence in the Child* (1953).

‡ *Grundzüge der Physiologische Psychologie* (1874), I, pp. 380 f.

§ The phrase is Sherrington's: cf. *The Integrative Action of the Nervous System*, 1906, pp. 314 f., and Hughlings Jackson, *Brain*, 1899, **22**, pp. 621 f.

‖ Cf. M. de Crinis, Die Entwickelung der Grosshirnrinde in ihren Beziehungen zur intellektuellen Ausreifung des Kindes, *Wiener Klinische Wochenschrift*, 1932, **45**, pp. 1163 f. J. L. Conel, *The Postnatal Development of the Human Cerebral Cortex*, 1941.

Defectives, for example, exhibit a " general cerebral immaturity," and their nerve-cells tend to be " visibly deficient in number, branching, and regularity of arrangement in every part of the cortex ".* After all, as Sherrington points out, much the same is true of almost every tissue of which the human frame is composed—of a man's skin, bones, hair, or muscles : each is of the same general character all over the body, although minor local variations are usually discernible.

4. Individual Psychology

Most of the writers I have so far mentioned were interested chiefly in problems of *general* psychology. The first to apply scientific methods to the study of *individual* psychology was Galton himself.† Spencer had maintained that the basic characteristics of the human mind were innate—transmitted as part of the common racial endowment. Galton went farther and maintained that individual differences in these characteristics might also be inherited or at least inborn. When he first commenced his inquiries on mental inheritance, the prevailing hypothesis among those who attempted to describe individual differences was, as we have seen, that of the faculty school. Galton quickly became convinced that a theory of wholly specific faculties was of itself quite inadequate to account for the facts he had accumulated.

As a corrective, he introduced the distinction between what he termed " general ability " and " special aptitudes." He recognizes three main sources of individual achievement — cognitive capacities (or " abilities "), emotional or affective characteristics (such as " interest " or " zeal "), and moral or conative characteristics (notably " a will to work "). He focuses attention mainly on the first, since " natural " ability must inevitably set a limit to what interest or industry, even in the most favourable circumstances, can possibly achieve. Most writers, he argues, " lay too much stress upon apparent specialities, thinking that, because a man is devoted to some particular pursuit, he could not have succeeded in anything else ; they might as well say that, because a youth has fallen in love with a brunette, he could not possibly have fallen in love with a blonde. He may or may not have had more natural liking for the former type of beauty than for the latter ; but it is as probable as not that the affair was mainly or wholly due to a *general* amorousness. It is just the same with intellectual pursuits ".

Galton does not deny the existence of special capacities. Indeed, he cites instances in which memory, literary ability, musical ability, and artistic talent, run through several members of the same family. In some cases the specialization may be due to family tradition or to home environment, though this could scarcely explain the " prodigies of memory " ; but, in the main, he says, the pedigrees and case-studies given in his book demonstrate " in how small a degree intellectual eminence can be considered as due to purely special powers ". His data suggest that individual differences in " natural ability " are distributed in accordance with the normal curve, i.e. much like differences in other human characteristics which are mainly innate, such as bodily size or stature ; and he prints a tabular classification of frequencies, which, he holds, " may apply to special just as truly as to general ability ".‡

Binet was greatly influenced by Galton's theories. Like Galton he distinguishes between *acquired* knowledge or skill (to be

* J. S. Bolton, *The Brain in Health and Disease*, 1914, pp. 79 f. and Figs. 52, 53. R. J. A. Berry and R. G. Gordon, *The Mental Defective*, 1931 and refs.

† Galton founded an anthropometric laboratory " for the measurement of human form and faculty " as early as 1884. At first the measurements included were chiefly physical: but psychological assessments (to be obtained with tests of discrimination, reaction-time, and the like, a questionnaire on mental imagery, and rating scales for more specific qualities) were later added to his scheme: cf., for example, *Inquiries into Human Faculty*, 1883, and J. M. Cattell's paper on " Mental Tests and Measurements " with a note by Galton in *Mind*, 1890, **15**, pp. 373-380. Galton's preference for the term " anthropometric " has led many to suppose that his scheme was limited to bodily measurements; but he makes it clear that he uses the word to cover all human characteristics, psychological and physiological as well as anatomical.

‡ F. Galton, *Hereditary Genius*, 1869, pp. 23 f., 35 f.

assessed by a " pedagogical scale ") and *native* abilities (to be assessed by a " psychological scale "). Like Galton, too, he firmly believes in the notion of *general* ability, which he contrasts with " partial aptitudes ". To designate this native general ability, he prefers the simple Spencerian name, " intelligence ". He gives us a popular but fairly clear account of " the meaning to be given to that word, so wide and comprehensive, intelligence. . . . Nearly all the phenomena with which psychology is concerned are phenomena of intelligence—sensation, perception, as much as reasoning. . . . And it would seem that in the phenomena of intelligence there is a fundamental faculty, deficiency in which is of the utmost importance for practical life: this faculty", he continues, " is variously described as common sense, judgment, the capacity of adjusting oneself to circumstances " (the last is Spencer's definition). Since it enters into every cognitive process, tests of any such process might in theory be used to assess it. But, he adds, " it is neither necessary nor possible to test *all* the child's psychological processes ". There is " a hierarchy among the diverse manifestations of intelligence " ; the more complex and more specialized mature at later stages in a progressive order that is relatively fixed. Hence the crucial test for an individual at any given stage of development will be the hardest cognitive processes of which he is capable.*

Such views did not escape criticism. A hypothesis which postulated *both* a general ability *and* a number of " partial " or " special " aptitudes seemed to assume two types of capacity where one would suffice. Writers on applied psychology, including the compilers of the more popular educational and psychiatric textbooks, usually rejected the notion of a central cognitive activity as a needless philosophical abstraction, and contended that a collection of special abilities or faculties accorded best with their practical experience. On the other hand, most of the writers on pure psychology treated the doctrine of special faculties as obsolete. There was, they held, and there could be, only one form of cognitive activity, though they failed to agree about its actual nature. The older associationists, such as Mill and his followers, maintained that it was " association "—the " process by which we learn " ; the younger members of the school, like Bain and Sully, maintained that it was " sensory discrimination ". Of their various opponents, both the neo-Kantian philosophers like Ward and the Herbartian psychologists like Stout and Adams, argued that it was " apperception " or " attention " : " when we feel, perceive, or remember a thing [says Ward] common sense thinks the object is the same, while the mental faculty differs ; actually there is only a single subjective activity—attention, and what we attend to are different presentations of the object ". Finally, several of Ward's disciples, like Maxwell Garnett, insisted that attention was essentially a conative process, and concluded that the apparent differences in " intelligence " were really differences in " will ". Similar divergences appeared in the writings of American psychologists ; and it is these alternative interpretations that account for the discrepant opinions cropping up in the 1928 Symposium to which Dr. Heim refers.

5. Statistical

Down to the beginning of the present century the arguments put forward by the various disputants were largely based on everyday impressions or deductions from physiological and biological principles. What was manifestly needed, therefore, was a more direct and rigorous method of deciding between the rival views. The obvious procedure consisted in a *combination* of the two novel techniques which Galton himself had devised ; in other words, the application

* A. Binet, La mesure en psychologie individuelle, *Rev. Philos.*, 1898, **46,** pp. 113-123. *L'étude expérimentale de l'intelligence* (1903); (with T. Simon) Methodes nouvelles pour le diagnostic du niveau intellectuel des anormaux, *L'Année Psychologique,* 1905, **11,** pp. 191 f., 245 f. To a French psychologist the phrase " common sense " is reminiscent of the scholastic doctrine (inherited from Aristotle) of a *sensus communis,* i.e., a " *general* perceptive faculty " (as Ross translates it). " Judgement " is the term which Binet proposes in place of the term " discrimination," used by most other contemporary psychologists to designate the essential cognitive element.

of the statistical method of correlation to results obtained with experimental tests.

The first to plan a systematic research on this twofold basis was J. M. Cattell. On his way back from his studies under Wundt at Leipzig, he spent some time working as Galton's assistant in the anthropometric laboratory, and the two collaborated in compiling a programme of mental tests. When Cattell returned to take up the first Chair of Psychology in the United States, he organized a scheme for testing freshmen entering Columbia and other colleges. The data thus collected were eventually analysed by one of Cattell's research students, Clark Wissler, and his investigation proved to be the first of the long series of inquiries in which correlational techniques were applied to test-results.

The primary object, so Wissler explains, was to " find a means whereby the fundamental elements of general and specific ability could be isolated and valued ". The correlations, however, proved to be rather low. On the whole they appeared to indicate that " whatever it is that makes for correlation in class standing seems to hold good generally ". But in Wissler's view the main lesson of the inquiry was " the need for a thorough correlation of tests of all kinds " based on " an exhaustive canvas of the whole field of human activity ".*

Verification by Factorial Techniques

Here we are concerned, not with the presence or absence of " special abilities " (the subject of the long controversy between Spearman and his opponents), but solely with that of the " general factor ". Taken together, the foregoing considerations—introspective, biological, physiological, and experimental—appeared to furnish strong presumptive evidence for a definite hypothesis which we can now formulate in the following terms: the efficiency of an individual depends largely on an abstract component or factor, termed for convenience "intelligence", which may be defined in terms of a trio of distinctions: it is (i) cognitive (in the sense already explained), and not affective or conative; (ii) it is general, i.e. common to all cognitive activities, and not limited to a particular group; (iii) it is innate, i.e. due to the individual's genetic constitution, not acquired as a result of opportunity or training. However, since each of these assumptions had been challenged, it seemed urgently desirable to procure, if possible, some direct empirical verification of each one.

(*i*) *General.* From the very start the point most often attacked was the assumption of an ability entering into all forms of cognitive process. To settle this question it seemed necessary to collect or construct tests of every aspect and level—i.e. motor as well as sensory, practical as well as intellectual, ranging from the simplest sensory or motor reaction to those of logical thought in its most developed forms. If, as some writers believed, the mind includes nothing but independent faculties or "group factors", such as " practical ability", "intellectual ability", and the like, the correlations between the practical tests should be positive, and the correlations between the intellectual tests should be positive, but the cross correlations between the first set and the second should be zero; and similarly for other special abilities: if what Thorndike called the " theory of natural compensation " (or " intellectual types ") was correct, then the cross correlations should be negative, because the " intellectual " type would be poor at the "practical" tests, and the "practical" type poor at the " intellectual " tests. What we actually found were *positive* correlations between *all* the processes tested. This at once put out of court the hypothesis of independent faculties or compensatory capacities, and confirmed the hypothesis of a general factor.†

* C. Wissler, The Correlation of Mental and Physical Tests, *Psychol. Rev. Mon. Sup.*, 1901, **3.** It is now clear that the research was wrongly planned. First, students are already selected for intelligence; and this must tend to eliminate any correlation resulting from differences in intelligence. Secondly, the processes tested were relatively simple (chiefly sensory discrimination, motor reaction, and memory), and these depend far less on intelligence than the more complex.

† Cf. C. Burt, Experimental Tests of General Intelligence, *Brit. J. Psychol.*, 1909, **3,** pp. 94-177; Experimental Tests of High Mental Processes and their Relation to General Intelligence, *J. Exp. Ped.*, 1911, **1,** pp. 93-112. *The Distribution and Relations of Educational Abilities* (1917).

(*ii*) *Cognitive.* The evidence I have summarized so far, however, does not of itself prove that the factor is a specifically cognitive factor ; it might be a factor common to other mental processes as well as cognitive. As we have seen, Maxwell Garnett, Pearsons' assistant and one of his ablest disciples, held that the general factor was far wider, and was in fact essentially a matter of Will, entering into moral as well as intellectual behaviour. This was at one time an extremely popular interpretation. After all, both teachers and parents have frequently doubted the existence of wide differences in sheer ability, and have assumed that, when a child makes little progress in his lessons, the cause is not so much lack of intellectual capacity as a lack of interest or effort.

In later experiments, therefore, we correlated assessments for intellectual performances with assessments for temperamental and moral qualities. This time the cross correlations, though small, were positive. But two points seemed clear : first, the correlations of intellectual performances with moral assessments were far too low to account for the high correlations *within* the intellectual performances themselves ; and secondly the small positive cross correlations were largely the result of a one-way influence : if the child shows no interest and exerts no effort, he naturally will not succeed ; but many a child may be keenly interested and exert himself to the utmost and yet fail to achieve success. It seems therefore that the general factor is mainly, though not perhaps wholly, cognitive.

(*iii*) *Innate.* How far the cognitive element in this factor depends on the individual's genetic constitution, and is therefore part of his unalterable endowment, is a problem about which there is far less agreement. Our ignorance of the genetic basis of mental characteristics is so great that any direct answer is scarcely practicable. We have therefore to be content with speculative inferences and indirect statistical verification.* But, after all, from a practical standpoint the crucial issue is that of prediction. Can we, when Tom enters the junior school at seven, or when at eleven plus it is time to allocate him to an appropriate secondary school—can we by the aid of our tests predict, not merely his intellectual efficiency during the coming years in the classroom, but his ultimate efficiency as an adult citizen ? And can we, as eugenists, go still farther, and predict the kind of children he is likely to have ?

To answer these questions we need "longitudinal studies"—case histories not merely of the same individuals but of the same families. I have myself been able to keep in touch, for nearly thirty years, with over 400 persons whom I first tested as children between 1915 and 1925, reassessing them from time to time, and even testing their own sons and daughters and other relatives. But before we examine the data so obtained, it is necessary to decide what precisely we wish to predict and what we are to take as the basis of our prediction.

There are in fact half a dozen varying quantities that we might seek to compare, and all are apt to be dubbed "intelligence". Much confusion would be avoided if, as I have suggested elsewhere, we extended Professor Spearman's practice and labelled each with a distinctive letter. We may perhaps distinguish them as follows :

(i) First, intelligence in the strict technical sense—i.e. the amount of innate general cognitive efficiency possessed by any given individual—a purely hypothetical quantity : following Fisher's convention (using Greek letters to denote hypothetical quantities and Roman to denote the empirical estimates), let us call it γ : by definition it cannot be altered by any post-natal influences, though of course its observable manifestations may be.

(ii) The actual measurement furnished by a single test or battery of tests, applied on a single occasion ; let us call it g_t : this is the quantity which critics evidently have in mind when they complain that measure-

* In the first lecture I was invited to give to this *Society* (The Inheritance of Mental Characters, EUGEN. REV., 1912, **4**, pp. 168-200) I attempted to summarize the results then obtained by these newer methods and urged the adoption of what was then a still newer approach, namely, the application of Mendelian principles to problems of mental heredity.

ments of intelligence are affected by coaching, by education, or the like.

(iii) The adjusted assessment of the child's intelligence, reached after checking the initial test result first by the teacher's judgment and then when necessary by a different test applied on a different occasion, g_c, say; this is what the psychologist uses (or should use) in diagnosing mental deficiency, and generally in predicting a child's future development.

(iv) The all-round ability of adults, assessed by tests and other means, regardless of how much is due to innate or acquired components respectively, g_a, say; it is this broader concept that is important in vocational guidance, and it was this that "intelligence tests" were used to measure among recruits during the recent war.*

(v) The statistical "general factor", i.e., "the factor common to all tests of a given battery",† g_s, say; it is this more abstract quantity with which Thomson and Thurstone are concerned in their controversies with Spearman.

(vi) "Intelligence as the layman understands the word", g_i.‡

Which are we to choose? Most investigators§ simply compare an initial set of test-measurements with a later set, each derived from written tests applied on a single occasion only, i.e. g_t. But the correlation between two such tests, even applied with only a minimal time interval, is still never more than about 0·85 or 0·90. Hence, much of the imperfection shown by such correlations must be due to defects in the methods of assessment; they throw no light (as is so often alleged) on the supposed instability of γ. After all, no experienced psychologist would diagnose a child as feebleminded on such a basis. He would invariably check the crude test-results by the child's case-history and the teacher's report, and in case of doubt retest him on a different day with one or more individual tests. Hence in what follows I shall be concerned chiefly with measurements of the third kind, g_c, i.e. assessments checked and corrected in this way. With these adjusted measurements the correlations are appreciably higher than those commonly reported for the unadjusted g_t.

For the cases I have been able to follow up, the correlations during the school period diminish progressively from 0·93 after one year to 0·74 after six years. The correlations with assessments secured in early adult life (i.e. after ten or fifteen years) average 0·61; and with assessments for the children of the original testees they average 0·32.

Correlations between parents and children are apt to vary somewhat erratically, in part no doubt because assessments of adult intelligence are bound to be more or less inaccurate. Let us therefore compare measurements for brothers and sisters who are all of school age. Miss Howard and I took a batch of 268 ten-year-olds each of whom had at least one sib attending school (i.e. aged eight to twelve) and who were so chosen as to be fairly representative of the total school population (excluding pathological defectives). They were divided into four equal groups: (i) bright, (ii*a*) bright average, (ii*b*) dull average, (iii) dull; and the middle groups were pooled. When any child had more than one sib, the sibs' assessments were averaged. The bivariate frequency-distribution so obtained, expressed in the form of percentages, is shown in the table below.

TABLE I

FREQUENCY DISTRIBUTION OF BRIGHT, AVERAGE, AND DULL SIBS

SELECTED CHILDREN	SIBS Bright	Average	Dull	Total
Bright	12·8	10·0	2·2	25·0
Average ..	11·2	29·6	9·2	50·0
Dull	1·3	8·9	14·8	25·0
Total ..	25·3	48·5	26·2	100·0

* Cf. P. E. Vernon and J. B. Parry, *Personnel Selection in the British Forces* (1949). Psychologists who are concerned chiefly with adult "intelligence" are, as a rule, sceptical of the measurability, and even of the existence, of a "pure innate *g*." But with adults assessments of "pure innate *g*" are almost impossible, and nearly always irrelevant.

† I take this definition from R. B. Cattell, *Factor Analysis* (1952), p. 424.

‡ This is the conception preferred by Dr. Heim (*loc. cit.*, pp. 30 f.).

§ For an impartial summary, see L. Carmichael (Ed.), *Manual of Child Psychology* (1946), pp. 586 f.

On Mendelian principles, it is easy to show* that, assuming variations in intelligence are produced by a large number of genes, then the expected proportions in the several rows would be 4 : 4 : 1, 3 : 8 : 3, and 1 : 4 : 4 respectively; i.e., with subgroups of 25 and 50 we should expect the figures to read 11·1, 11·1, 2·8; 10·7, 28·6, 10·7; and 2·8, 11·1, 11·1. In the middle row the observed figures conform quite closely with expectation. The excess of bright sibs in the top row and of dull sibs in the bottom row is probably due to the fact that like tends to marry like. Assortative mating would obviously raise the apparent correlation. On the other hand, the inaccuracies in the assessments would tend to lower it. Allowing for such minor disturbances, the frequencies clearly suggest that we are dealing with a trait that is, in the main, the effect of multi-factor or "polygenic" inheritance.

Figures like the foregoing cannot of themselves provide conclusive proof that the characteristic we are seeking to assess is an innate and therefore permanent characteristic. But they plainly offer strong corroboration for what is, on antecedent grounds, a highly plausible hypothesis. As with most generalizations in the field of individual psychology, our acceptance of such a conclusion must rest, not on any one decisive inquiry, but on inferences reached by half a dozen different lines of approach and set forth in numerous independent researches. The evidence so far available I have summarized in some detail in other publications,† and accordingly I need not repeat it here. Roughly speaking, an impartial analysis would seem to indicate that very nearly 90 per cent of the variance exhibited by assessments for a complete age-group is attributable to the genetic constitution of the various individuals and that approximately half of this (i.e. 45 per cent of the variance) is attributable to what is loosely called heredity (i.e. predictable from characteristics of near relatives).

Finally, what is the actual distribution of "intelligence" as we have defined it? Like variations in stature, variations in intelligence (γ), as Galton himself believed, follow to a close approximation the normal curve. But, what is much more important, not only is there "a continuity of natural ability," but "the range of mental power between the greatest and least of English intellects is enormous."‡ Surveys carried out in London and elsewhere show that, if we take a random sample of 1,000 children aged ten by the calendar, and exclude all pathological cases, the dullest will have a mental age of only five, the brightest a mental age of approximately fifteen, and between these two extremes every intermediate grade will be found. There is a larger proportion of bright children in the upper classes and a smaller proportion in the lower, but the several classes exhibit a wide overlapping. Moreover, were we to divide the total population into the non-professional and professional classes, then, simply because the former are far more

* The mechanism assumed is that (except for pathological cases) intelligence, like stature, is the effect of many pairs of genes (n let us suppose), such that one in each pair, D_1, D_2, ... D_n, say, makes a small addition to the individual's intelligence, while the alternative member of the pair, d_2, d_2, ... d_n, produces a small reduction. With random mating, and no one-sided dominance, the grades that could exist, and their several frequencies, would be given by the product of $(D_1 + d_1)^2 (D_2 + d_2)^2 \ldots (D_n + d_n)^2$; omitting subscripts, the most intelligent would be represented by D^{2n}, the next by $D^{2n-1} d$, ... and the least by d^{2n}. If n in large, the distribution will evidently tend towards that given by the normal curve. From the above formulation it also follows that, if we reclassify the total distribution, sot that the proportionate frequencies are expressed by the expansion of $(\Delta + \delta)^2$, i.e., $1\Delta^2 + 2\Delta\delta + 1\delta^2$, then the expected results of further random matings can be deduced from a simplified model involving only a single gene pair. Cf. R. A. Fisher, *Trans. Roy. Soc. Edin.*, **52,** pp. 399-433. Somewhat similar results have been reported by Dr. Fraser Roberts, starting with different proportions (*An Introduction to Medical Statistics*, 1940, pp. 233-238).

It should be added that my own figures suggest some small degree of one-sided dominance, much as has been noted in stature. But this, if present, does not disturb the main conclusion. Had the uncorrected test-measurements been used, the apparent correlation would have been higher, presumably because the uncorrected test-results are to some small extent influenced by the cultural environment.

† Cf. Intelligence and Fertility, *Occasional Papers on Eugenics* (1946), pp. 36 f., and Ability and Income, *Brit. J. Educ. Psychol.*, 1943, **13.** Pp. 88 f.

‡ *Hereditary Genius*, pp. 26 f.

numerous, I calculate that, in the former, we should find approximately three times as many "very bright" children (say, sufficiently able to pass an honours examination) as in the latter.*

If the views that I have put forward are correct, it is clear that these inequalities in native ability, as Plato long ago foresaw, present the democratic state with profound and far-reaching problems—problems which even today are scarcely recognized and which have been attacked only in the most tentative fashion. So far as the child is concerned, it is plainly imperative that the education authority should seek to determine as accurately as possible the natural potentialities of each one, and, having done so, provide him with the education best suited to his needs, and finally, before it leaves him, help to select that kind of vocation for which his gifts may seem to have marked him out. In this way, and in this way alone, can we hope to realize "that ideal polity in which the apparent injustices of nature are reconciled and harmonized by the wisdom and justice of man."

* For actual figures see Ability and Income, *loc. cit. sup.*, pp. 84 f.